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Docket No.: 861975-101

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Serial No.: 09/887,695

Applicant: Obara et al.

Title: ANTI-FRICTION BEARING

Filed: September 24, 2001

Examiner: Andrews, Melvyn J

Group Art Unit: 1742

Docket No.: 861975/101

I hereby certify that this correspondence is being deposited with the United States Post Office as first class mail in an envelope addressed to: Mail Stop AF, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on Date: November 11, 2003

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DECLARATION UNDER 37 C.F.R. §1.132

(37 C.F.R. §1.132 and M.P.E.P. §716)

Sir:

I, Yutaka Daikuhara, hereby declare that I am a co-inventor of the subject matter disclosed and claimed in United States Patent Application Serial No. 09/887,695 entitled Anti-Friction Bearing and that I have reviewed the Final Office Action dated June 12, 2003, including the prior art references cited therein.

I am a citizen of Japan, having a mailing address at 4106-73 Miyota, Oaza, Miyota-Machi, Kitasaku-Gun, Nagano-Ken 389-0293 Japan.

I am a graduate of Nagano National College of Technology, Department of Mechanical Engineering.

I have been employed by Minebea Co., Ltd. since March 21, 1971.

I have been engaged in the First Manufacturing Dept of the Company from October 1, 1988 to October 21, 1992; and in the Bearing Manufacturing Dept. of the Company from October 21, 1992 to present time, where I am the Adjunct Department-Manager since March 21, 1998.

I establish that the amount of retained austenite present in the martensitic stainless steel used to manufacture a component of an anti-friction bearing for a rotary support section of a computer peripheral device extremely affects noise characteristics and vibration characteristics of the anti-friction bearing.

The claimed invention relates to an anti-friction bearing for a rotary support section of a computer peripheral device.

The rotary support section typically supports a spindle revolving at very high rates, which can exceed 10,000 rpm.

It is well known in the art that bearings which are incorporated in spindle motors for hard disk drives are exposed to conditions under which the raceway grooves of the inner and outer rings and the rolling elements are repeatedly subjected locally to stress. Accordingly, surface roughness develops due to the rolling fatigue of the raceway groove faces and the surfaces of the rolling elements, resulting in an increase in vibration and deterioration of the acoustic characteristics.

It is also well known in the art that in high precision machines, especially in hard disk drive devices, strict vibration and acoustic characteristics requirements have to be complied with.

The claimed anti-friction bearing for a rotary support section of a computer peripheral device includes at least one component made of martensitic stainless steel composed

of 0.60 to 0.75 % by weight carbon, 10.5 to 13.5 % by weight chromium, 1.0 % by weight or less silicon, 0.3 to 0.8 % by weight manganese, the remainder of the composition being iron and inevitably introduced impurities, containing eutectic carbide particles of 10 μ or less in diameter, having titanium and oxygen concentrations of 10 ppm or less respectively, having a hardness of HRC 58 or higher, and having more than 0% and less than 10 % by volume retained austenite.

I establish that the performance of a bearing is affected by the presence of retained austenite which decomposes over time under the stress which is applied to a bearing during operation of a hard disk drive. When retained austenite decomposes, a volume expansion tends to take place causing a variation in dimension of a bearing. This variation in dimension reduces the precision in shape and/or configuration of the rotating faces of a bearing, causing vibration and, consequently, deterioration of its acoustic characteristics. As a result, I establish that an anti-friction bearing of the present invention should have a reduced quantity of retained austenite to be suitable for use in a rotary support section of a hard disk drive device or other high precision equipment.

Table I and Figure 1 show the results of the measurement of vibration and noise (quietness) of several samples of anti-friction bearings by way of measuring Anderon values. The measurement technique was based on the ABMA (The Anti-Friction Bearing Manufacturers Association, Inc.) standard. Tests were performed with the inner ring being rotated at a prescribed speed, with the outer ring held stationary. A probe measured the vibration (noise) on the outer ring. The results were recorded for the high and medium bands, as shown in Table I and Figure 1. The high band is defined as a range of 1800 – 10,000 HZ, and the medium band is defined as 300 – 1800 HZ.

In Table I and Figure 1, Sample A is an anti-friction bearing formed in accordance with the claimed invention. Samples B, C and D are bearings manufactured by NSK Ltd. for use in automobiles. Sample A has a claimed composition. Compositions of Samples B, C and D are shown in Table II.

As can be seen from Table II, bearings of Samples B, C and D are compatible with the bearings disclosed in U.S. Patent No. 5,030,017 (hereinafter "the Murakami reference").

Anderon values for components of Sample A, having less than 10 % by volume of retained austenite, are significantly better compared to Anderon values of Samples B, C and D. Therefore, bearings having 10-25% by volume of retained austenite have significantly higher, i.e., worse, vibration and noise characteristics than bearings having less than 10% by volume of retained austenite.

Table III and Figure 2 show the results of the measurement of vibration and quietness of several samples of anti-friction bearings by way of measuring acceleration values (G-values). Each test sample was set in a rotary arm of the test apparatus. While the outer ring was rotated at a rate of 1800 rpm, a measuring probe was pressed against the edge surface of the inner ring from the axial direction, and the acceleration (G value) of the vibration of each test sample was measured by means of a vibro-meter. The smaller the G value, the less vibration is produced and the greater the quietness. Compositions of Samples A and E are shown in Table IV.

As can be seen from Table III and Figure 2, G-value for components of Sample A, having less than 10 % by volume of retained austenite, are significantly better compared to G-value of Sample E. Therefore, bearings having 10-25% by volume of retained austenite have significantly higher, i.e., worse, vibration and noise characteristics than bearings having less than 10% by volume of retained austenite.

Table V and Figure 3 show the results of measuring the levels of sound pressure generated by spindle motors incorporating anti-friction bearings of Sample A and Comparative Sample E, which differ in the quantity of retained austenite (see Table IV). The smaller the level of sound pressure, the less noise is generated by the motor.

As can be seen from Table V and Figure 3, levels of sound pressure measured for spindle motors incorporating anti-friction bearings of Sample A, having less than 10 % by volume of retained austenite, are significantly better compared to levels of sound pressure for spindle motors incorporating anti-friction bearings of Sample E. Therefore, spindle motors incorporating bearings having 10-25% by volume of retained austenite have significantly higher, i.e., worse, vibration and noise characteristics than spindle motors incorporating bearings having less than 10% by volume of retained austenite.

Conclusion

I declare that the claimed anti-friction bearing for a rotary support section of a computer peripheral device including at least one component made of martensitic stainless steel composed of 0.60 to 0.75 % by weight carbon, 10.5 to 13.5 % by weight chromium, 1.0 % by weight or less silicon, 0.3 to 0.8 % by weight manganese, the remainder of the composition being iron and inevitably introduced impurities, containing eutectic carbide particles of 10 μ or less in diameter, having titanium and oxygen concentrations of 10 ppm or less respectively, having a hardness of HRC 58 or higher, and having more than 0% and less than 10 % by volume retained austenite; has significantly improved vibration and acoustic characteristics because its level of retained austenite is reduced to being below 10% by volume.

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I also declare that bearings made of stainless steel having a higher level of retained austenite are not suitable to be used in a rotary support section of a hard disk drive device because of their poor vibration and acoustic characteristics.

I declare further that all statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true and these statements were made with the knowledge that willful false statements so made are punishable by fine, imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signature: Yutaka Daikuhara
Yutaka Daikuhara

Date: 2003, Dec, 5